REMARKS

By this response, claim 20 has been amended to incorporate the features of claim 31; leaving claims 1-30, 34-40 and 48-51 pending in the application. The claim amendments do not raise any new issue that would require further search and/or consideration by the Office. Accordingly, the amendments should be entered. Favorable consideration is respectfully requested.

Claim 51

Claim 51 is not included in either one of the two grounds of rejection set forth at pages 2-5 of the Office Action. Accordingly, claim 51 is assumed to be allowed.

First Rejection Under 35 U.S.C. § 103

Claims 20-37, 39, 40 and 48-50 stand rejected under 35 U.S.C. § 103(a) over U.S. Patent No. 4,011,077 to Kaufman ("Kaufman"). Claims 31-33 have been cancelled. The rejection is respectfully traversed.

Amended claim 20 recites a process for preparing high density green compacts comprising "(a) subjecting a composition of an iron or iron-based powder, wherein less than about 5% of the powder particles have a size below 45 μm, and a lubricant added to the powder in an amount between about 0.05% and about 0.6% by weight, to uniaxial compaction in a die at a compaction pressure of at least about 800 MPa; and (b) ejecting the green body from the die" (emphasis added). The claimed process comprises uniaxially compacting a composition of an iron or iron-based powder and a lubricant to produce a green body. The lubricant is added to the powder in an amount between about 0.05 and about 0.6% by weight. Less than

about 5% of the powder particles have a size below 45 μm. The compaction pressure is at least about 800 MPa.

The recited amount of lubricant added to the powder is advantageous as compared to high amounts of lubricants. When high amounts of lubricants are used, it is not possible to achieve high densities because the lubricant is much lighter than the powder and, consequently, will occupy a large volume of the compacted product.

Embodiments of the process recited in claim 20 can produce high-density green bodies using the recited composition in which less than about 5% of the powder particles have a size below 45 μm, an internal lubricant in an amount of about 0.05% and about 0.6% by weight, and a uniaxial compaction pressure of at least about 800 MPa. Green bodies formed from the compacted "coarse particles," to which an internal lubricant has been added, can be ejected from dies using low ejection forces, and have desirable surface finishes.

The claimed process resulted from the inventors' unexpected finding that coarse powders (i.e., powders containing at most a small amount of fine particles) can be compacted to produce green bodies that have high densities and shiny surfaces. For many applications, a high density is desirable because it can provide improved mechanical properties. Shinny (i.e., not deteriorated) surfaces are desirable for industrially used products. However, when a powder is compacted to high density using a high compaction pressure, the ejection force needed to eject the compacted body from the die affects the surface finish of the compacted body. The higher the ejection force, the greater is the risk that a deteriorated compact surface will be obtained.

The specification describes comparative test results that demonstrate unexpected results that can be provided by embodiments of the claimed process. As explained at page 2, lines 6-14, of the present specification, the inventors unexpectedly determined that high density green compacts can be produced by using the recited coarse powder wherein less than about 5% of the powder particles have a size below 45 µm, and a compaction pressure of at least about 800 MPa, which is an exemplary "high" compaction pressure.

Unexpected results provided by the claimed process are demonstrated by the test results given in Examples 1 and 2. In Example 1 described at pages 6-7 of the present specification, two different iron-based powder compositions according to the claimed process were compared with a standard iron-based powder composition. All three compositions were produced with Astaloy Mo, and graphite and a lubricant were added to the compositions. For one of the powder compositions, particles of the Astaloy Mo with a diameter less than 45 microns were removed ("+45 micron powder"). For another powder composition, particles of Astaloy Mo having a size of less than 212 microns were removed ("+212 micron powder"). Fig. 1-1 shows the relationship between green density (GD) and compaction pressure for the three powders. A clear density increase at all compaction pressures was obtained with the +212 micron powder.

Fig. 1-2 shows the relationship between the ejection force (F_e) and compaction pressure. As shown, the ejection force for the compacts produced with the +212 micron powder is considerably lower than the ejection force needed for compacts produced from the standard iron-based powder composition including about 20% of the particles sized less than 45 microns. Moreover, the ejection force

decreases with increasing compaction pressure, which is opposite to that for the standard composition. The ejection force needed for compacts produced from the +45 micron powder is also lower than that of the standard powder.

The compacts produced by compacting the standard powder at a pressure above 800 MPa also have deteriorated surfaces. In contrast, the compacts obtained when the +45 micron powder is compacted at a pressure above 800 MPa have a more desirable surface. The test results demonstrate that components without deteriorated surfaces can be obtained by the reduction of, or elimination of, particles smaller than 45 microns.

Example 2 is described at page 7 of the present specification. As shown in Figs. 2-1 and 2-2, respectively, higher green densities and lower ejection forces are obtained using the +45 micron powder than with the powder composition containing the standard powder. Also, components produced from the standard powder have deteriorated surfaces at all compaction pressures.

Kaufman does not disclose or suggest the above-described problems that occur with compaction at high compaction pressures, much less provide a solution to these problems. Kaufman also does not recognize any advantages provided by the reduction, or elimination, of particles smaller than 45 microns with respect to compaction pressure, density and surface finish of compacted bodies produced from such powders. The powder composition disclosed in Kaufman is substantially different from the powder composition recited in claim 20. Kaufman discloses that the base-iron powder should have a particle size of about -100/+325 mesh (i.e., 45-150 μm; see column 6, lines 31-32). Kaufman does not disclose the fraction of fines (i.e., particles smaller than 45 μm in the powder). Kaufman also discloses that this

particular particle size range "facilitates promoting an intimate contact between each particle of pre-alloyed powder with a particle of the base-iron powder" (emphasis added; see column 6, lines 32-34). In other words, Kaufman uses two separate powders.

Kaufman combines a master alloy powder material with a relatively low carbon base iron powder for compaction. Kaufman's powder is a mixture of two different types of iron powders. It is Applicants' understanding that Kaufman's process would be inoperable if only type of powder were used. However, embodiments of the claimed process can use one iron (or iron-based) powder.

Furthermore, an essential feature of Kaufman's pre-alloyed powder is that each particle of the powder is coated with a low-melting alloying agent, such as copper, in order to avoid carbon diffusion. See, e.g., column 3, line 33 to column 4, line 38. Accordingly, Kaufman would have led one having ordinary skill in the art away from a process that does not require such coating.

Kaufman discloses a compaction pressure of only 412-484 MPa (30-35 tsi, see column 6, lines 65-67), which is much lower than the compaction pressure of at least about 800 MPa recited in claim 20.

Kaufman is silent regarding the surface finish of the compacts.

Rutz fails to cure the above-described deficiencies of Kaufman with respect to the claimed process. Rutz discloses a method of making a sintered metal component. Rutz's method comprises compacting metal powders at an elevated temperature of up to about 370°C using conventional compaction pressures, and then sintering the compacted bodies using standard powder-metallurgical techniques. See the Abstract, for example.

Rutz discloses that powders of the Ancorsteel 1000 series are suitable powders for use in the method (column 2, line 49). In the Examples (see, e.g., Tables I-III), the powders Ancorsteel 85 HP and Ancorsteel 4600 are disclosed. Each of these particular powders is a "conventional" powder, i.e., it contains at least 20% fines (i.e., particles having a size of less than 45 μm). For the Examiner's convenience, Applicants have attached data sheets for Ancorsteel 85, 1000 and 4600 powders. The data sheets show the sieve distribution (w/o) of powders. As shown, Ancorsteel 85, 1000 and 4600 powders contain 20%, 22% and 24%, respectively, of particles smaller than 45 µm. Accordingly, none of these powders contains less than about 5% of powder particles having a size below 45 µm.

In Rutz, the compaction is performed at elevated temperatures and comparatively high compaction pressures are used. The attached Ancorsteel data sheets report compaction of the powders at ambient temperature. The data sheets do not disclose a compaction pressure of more than 700 MPa. As such, the Office Action has established no suggestion or motivation to use the Ancorsteel powders at a compaction pressure above 700 MPa, or for compaction at ambient temperature (as recited in claim 38 discussed below).

Rutz also does not disclose the compacts have any particular surface finish.

Accordingly, Kaufman discloses the compaction of a powder mixture of two different types of iron powders, in which the particle size varies from 45 to 150 μm, at comparatively low compaction pressures, to produce products having comparatively low densities. In contrast, Rutz discloses the compaction of conventional powders containing at least 20 % by weight of fines, at higher pressures and elevated temperatures. Applicants submit that Rutz does not suggest modifying Kaufman's

process in a manner to result in the claimed process, which uses a coarse iron or iron-based powder, an internal lubricant in the claimed amount, and uniaxial compaction at a pressure of at least about 800 MPa. The claimed process unexpectedly can produce compacts that have a desirable surface finish. The applied references fail to recognize these advantageous effects.

For at least the foregoing reasons, the process of claim 20 is patentable over the applied references. Claims 21-30, 39, 40 and 48-50 depend from claim 20 and thus are also patentable for at least the same reasons as those for which claim 20 is patentable. Therefore, withdrawal of the rejection is respectfully requested.

Second Rejection Under 35 U.S.C. § 103

Claims 20 and 38 stand rejected under 35 U.S.C. § 103(a) over Kaufman in view of U.S. Patent No. 6,638,335 to Ozaki et al.

Amended claim 20 includes the features of claim 31. Claim 38 depends from claim 20. As claim 31 is not rejected under this ground of rejection, this rejection is moot. **Claim 38 is patentable.**

Conclusion

For the foregoing reasons, allowance of the application is respectfully requested. Should there be any questions concerning this response, to expedite prosecution, the Examiner is respectfully requested to contact the undersigned at the number given below.

Respectfully submitted,

BUCHANAN INGERSOLL PC

Date: April 10, 2006

By:

Edward A. Brown
Registration No. 35,033

P.O. Box 1404
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www.hoeganaes.com

Data Sheet

Ancorsteel® 85 HP

Ancorsteel 85 HP *is a water atomized, prealloyed low-alloy steel powder for high performance applications. The prealloyed 0.85 w/o molybdenum addition allows exceptionally high compressibility and provides good response to heat treatment. Ancorsteel 85 HP is a good base powder for a wide range of hybrid alloy systems.*

Typical Analysis and Properties

Composition (weight %) (w/o)

C	Mn	Mo	O
<0.01	0.12	0.86	0.08

Apparent Density

2.97 g/cm^3

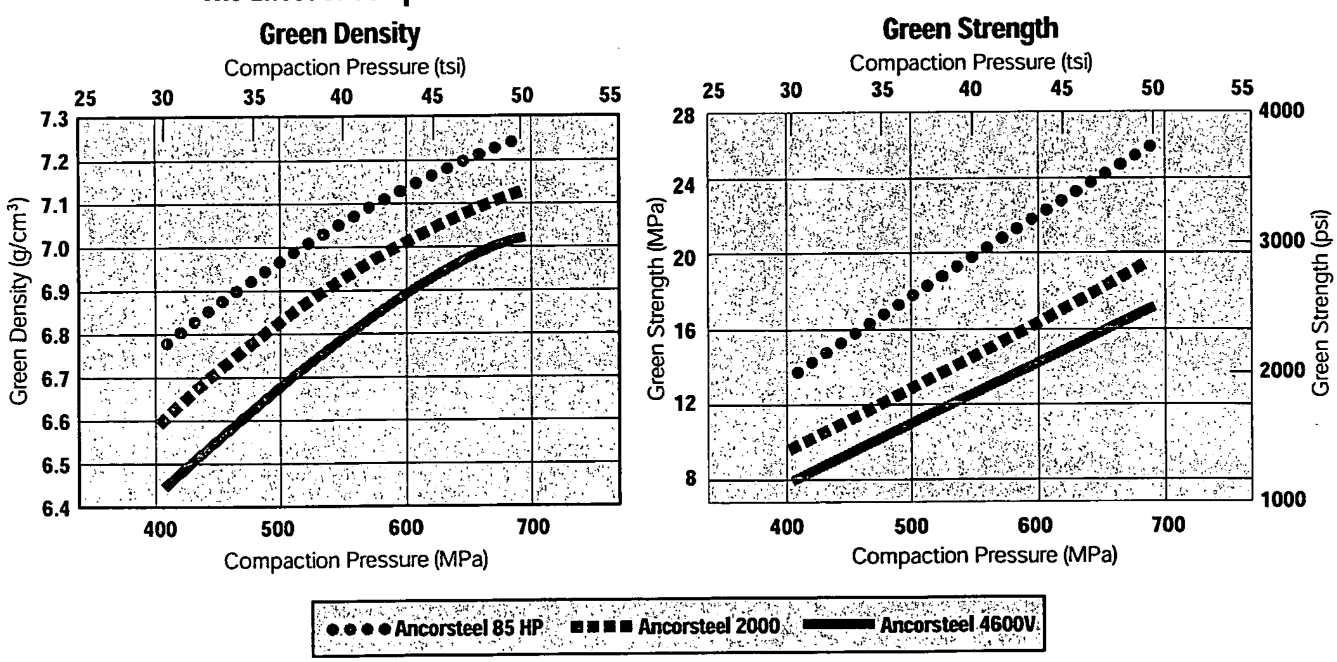
Flow Rate

25 s/50g

Sieve Distribution (w/o)

Micrometers	+250	-250 /+150	-150 /+45	-45
U.S. Standard Mesh	(+60)	(-60 +100)	(-100 /+325)	(-325)
	Trace	10	70	20

The Effect of Compaction Pressure on Ancorsteel 85 HP with 0.5 w/o Zinc Stearate



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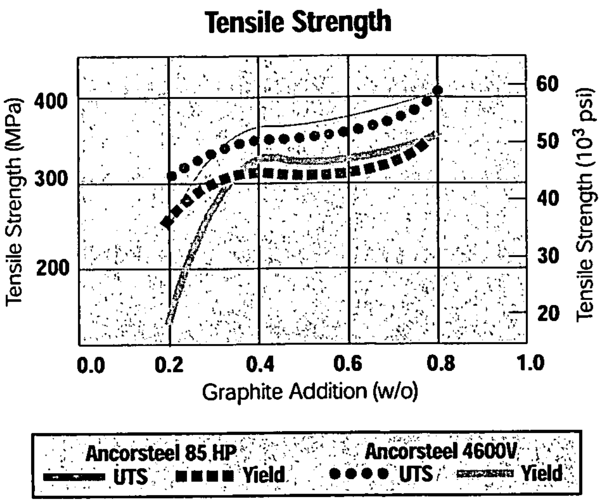
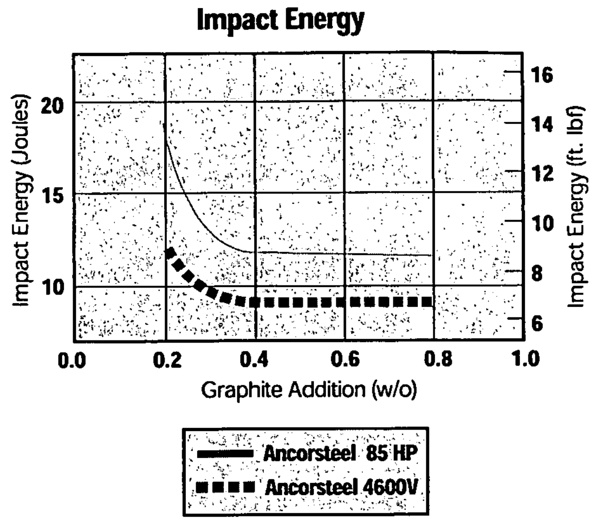
Ancorsteel 85 HP

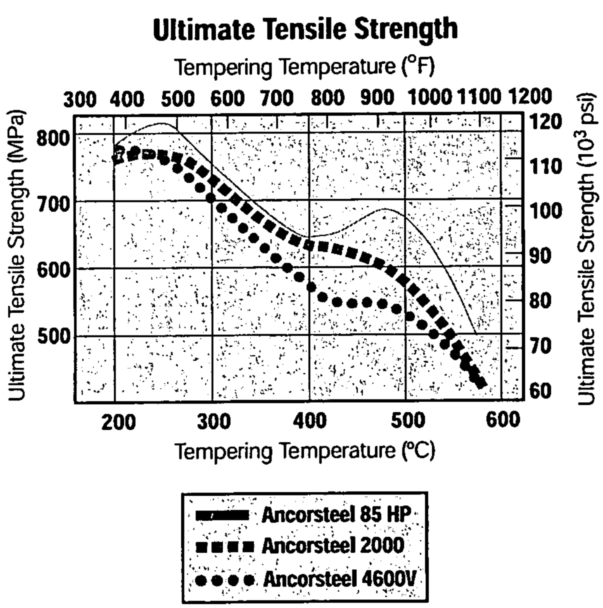
Properties of Heat Treated Compacts of Ancorsteel 85 HP

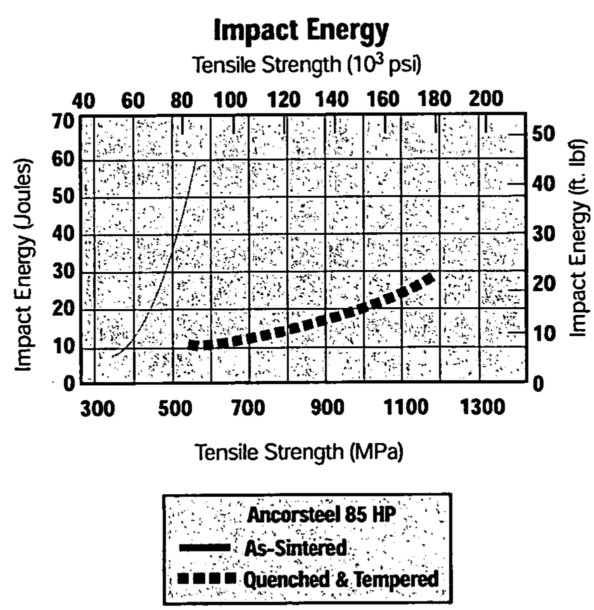




All specimens were compacted at a pressure of 550 MPa (40 tsi).

Response to Heat Treatment

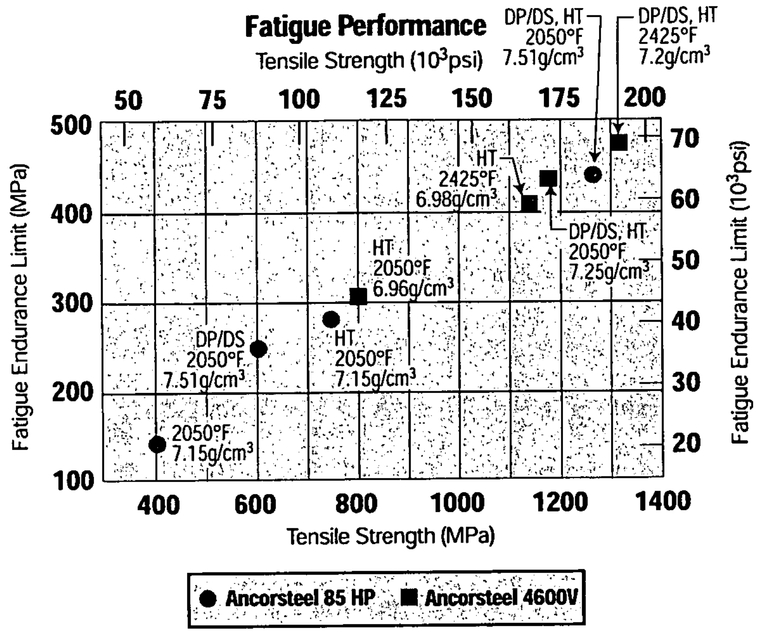




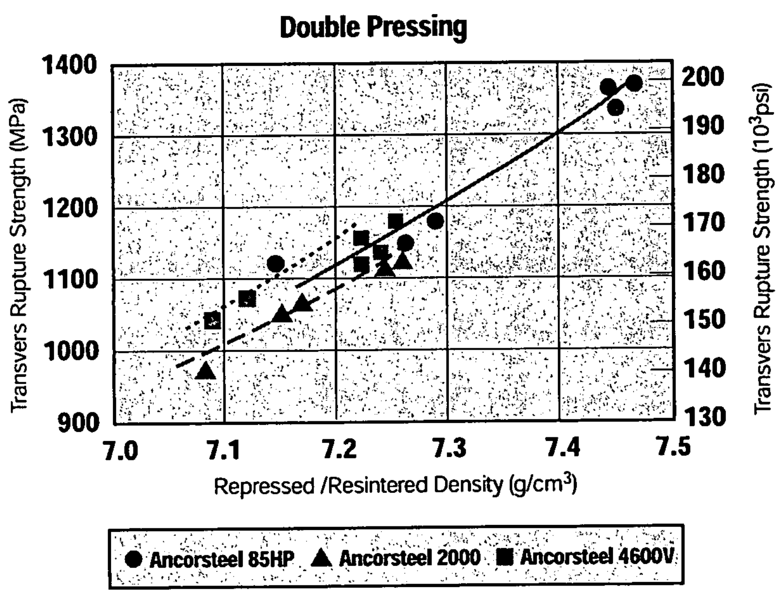
Powders with a 0.6 w/o graphite addition were compacted at a pressure of 550 MPa (40 tsi).
Heat treatment was performed at 900°C (1650°F) for 30 minutes in dissociated ammonia followed by quenching in oil preheated to 60°C (150°F). Tempering was performed for 60 minutes in argon to prevent decarburization.

Ancorsteel 85 HP

Properties of Heat Treated Compacts of Ancorsteel 85 HP



All compacts were prepared with a 0.6 w/o graphite addition. Processing conditions are shown for each data point.

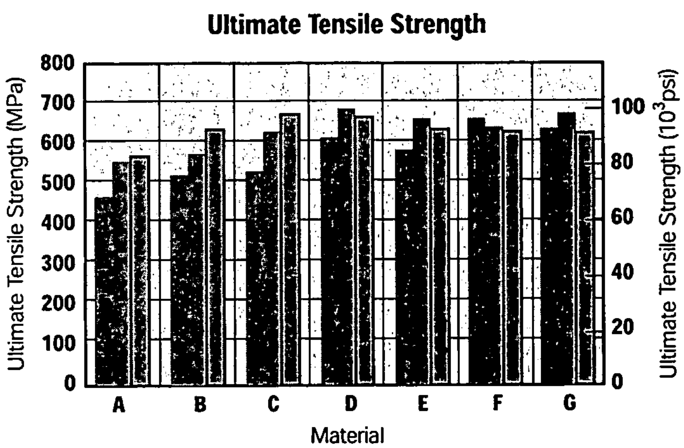


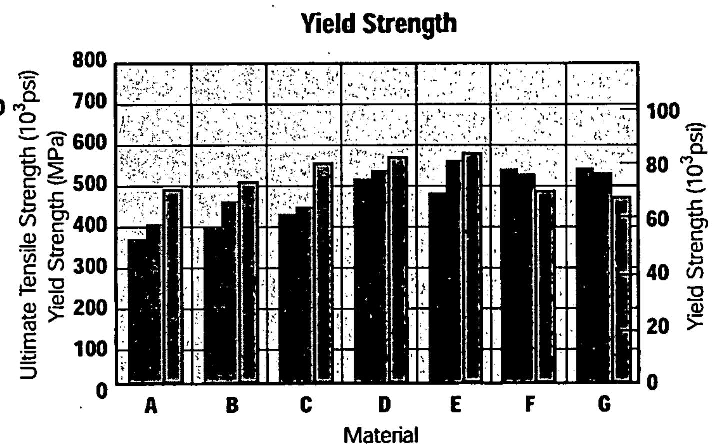
Powders with a 0.6 w/o graphite addition were compacted initially at 620 MPa (45 tsi) followed by presintering at a range of temperature from 590- 870°C (1100- 1600°F) The specimens were repressed at 620 MPa (45 tsi) and sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia.

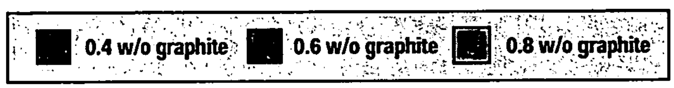
Ancorsteel 85 HP

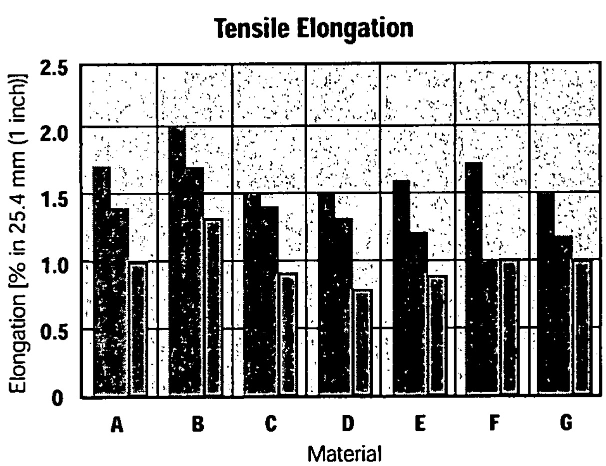
As-sintered Properties of Compacts of Ancorsteel 85 HP at a 7.0g/cm³ Density

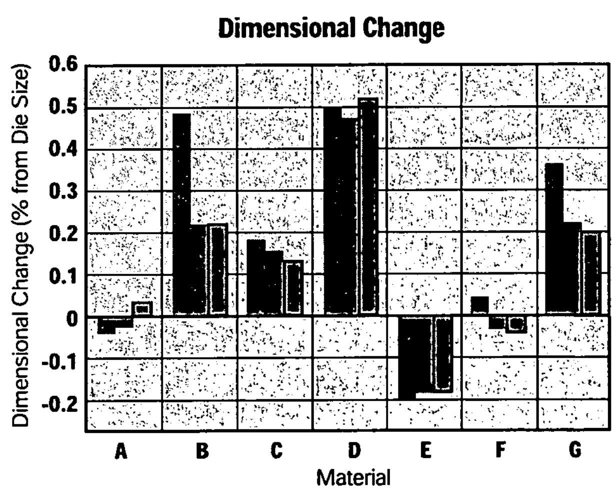
Material	A	B	C	D	E	F	G
Nickel (w/o)	2	0	2	2	4	4	4
Copper (w/o)	0	2	1	2	0	1	2











All specimens were sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia.

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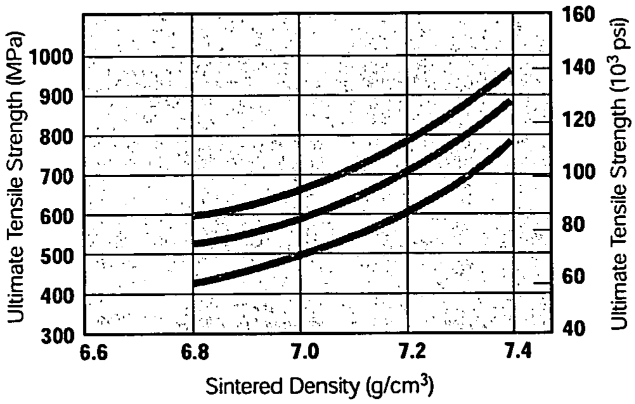
Ancorsteel 85 HP

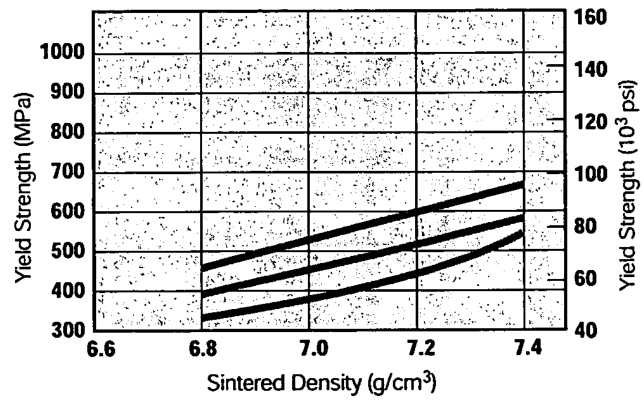
The Effect of Density on Properties of Sintered Compacts of Ancorsteel 85 HP

Material	A	C	F
Nickel (w/o)	2	2	4
Copper (w/o)	0	1	1
Graphite (w/o)	0.6	0.6	0.4
Color Legend	▬	▬	▬

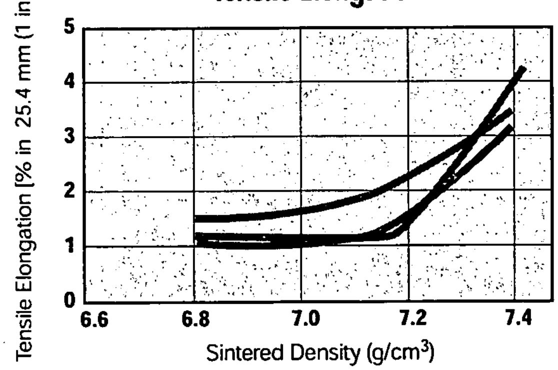
Ultimate Tensile Strength



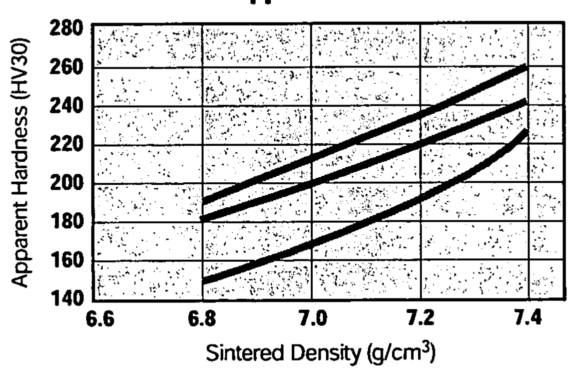
Yield Strength



Tensile Elongation



Apparent Hardness

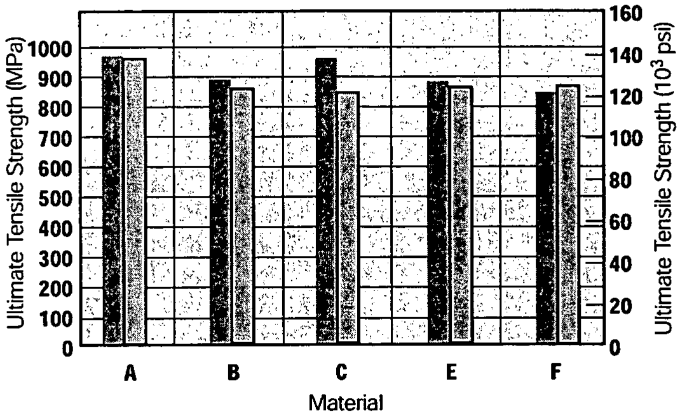


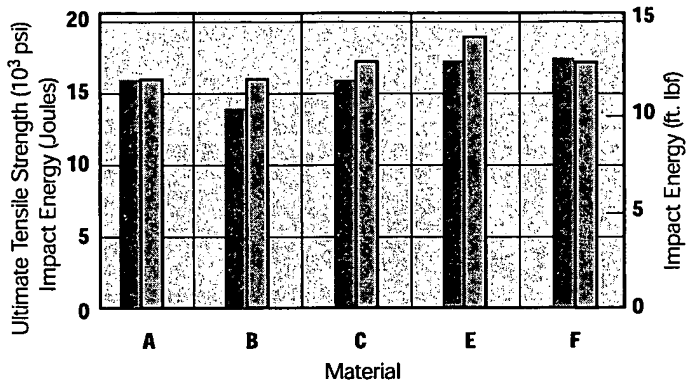
All specimens were sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia. [For sintered densities greater than 7.2 g/cm³, initial compaction was performed at 620 MPa (45 tsi) followed by presintering at 760°C (1400°F). The specimens were repressed at 620 MPa (45 tsi) and sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia].

Ancorsteel 85 HP

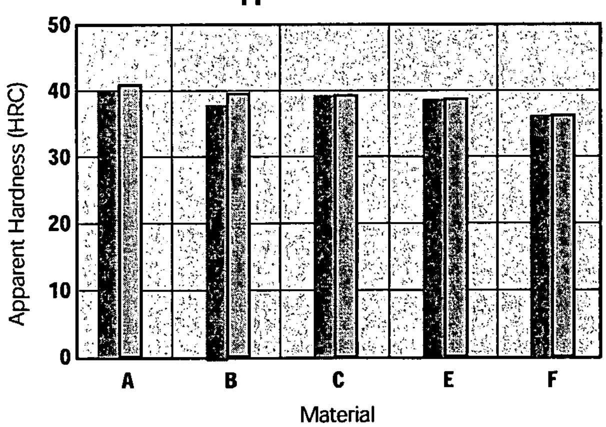
Properties of Heat Treated Compacts of Ancorsteel 85 HP

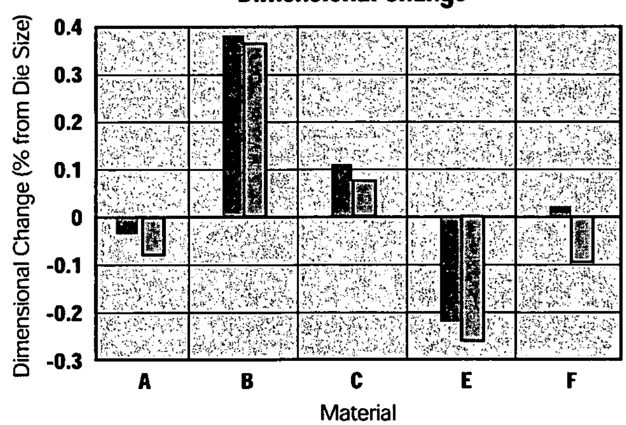
Material	A	B	C	E	F
Nickel (w/o)	2	0	2	4	4
Copper (w/o)	0	2	1	0	1





0.4 w/o graphite
0.6 w/o graphite





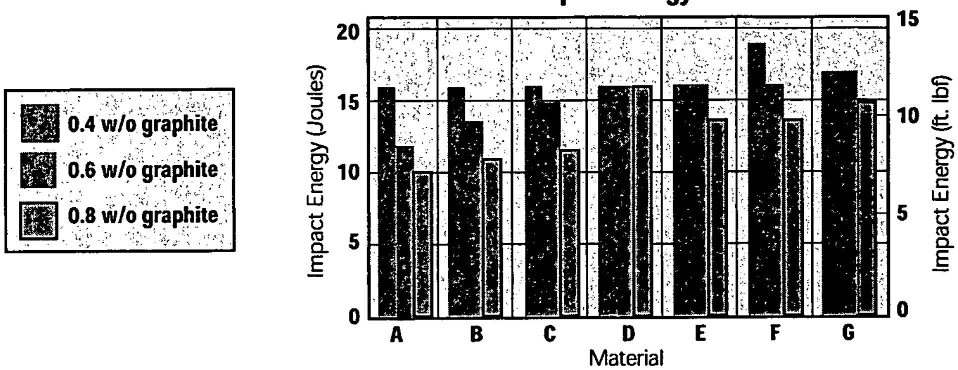
All specimens were compacted at 620 MPa (45 tsi) and sintered for 30 minutes in dissociated ammonia. Heat treatment was performed in a production furnace at 840°C (1550°F) in an endothermic gas atmosphere followed by quenching in oil preheated to 60°C (140°F). Tempering was carried out at 200°C (400°F) in air.

Ancorsteel 85 HP

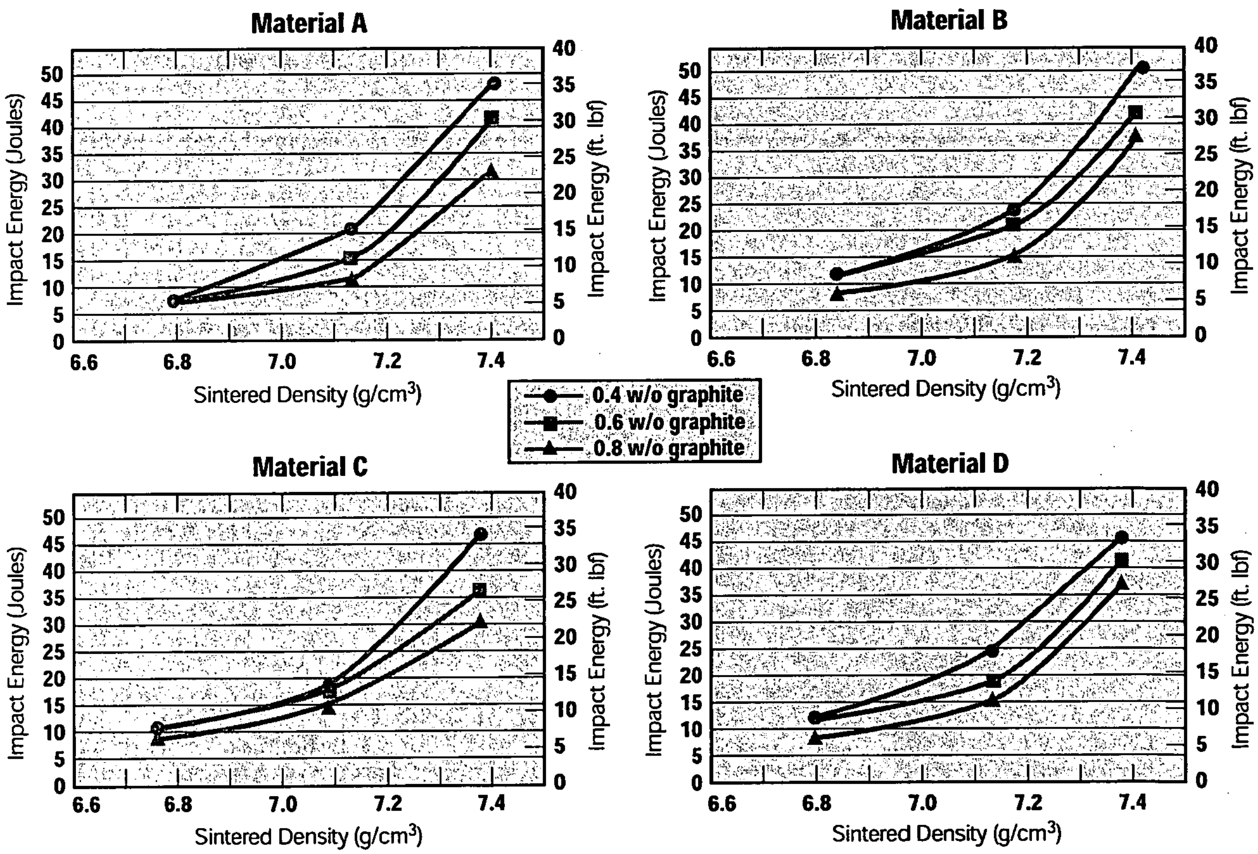
Properties of Sintered Compacts of Ancorsteel 85 HP at a Density of 7.0 g/cm³

Material	A	B	C	D	E	F	G
Nickel (w/o)	2	0	2	2	4	4	4
Copper (w/o)	0	2	1	2	0	1	2

Impact Energy



The Effect of Sintered Density on Impact Properties



All specimens were sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia. [For sintered densities greater than 7.2 g/cm³, initial compaction was performed at 620 MPa (45 tsi) followed by presintering at 760°C (1400°F). The specimens were repressed at 620 MPa (45 tsi) and sintered at 1120°C (2050°F) for 30 minutes in dissociated ammonia].

IMPORTANT NOTICE: The data shown are based on laboratory processing standard test specimens. Results may vary from those obtained in production processing.

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Data Sheet

Ancorsteel 1000

Ancorsteel 1000 *is the workhorse of our atomized powders, the material that had advanced P/M into the modern age of higher density compacts. More P/M components have Ancorsteel 1000 as their base than any other atomized powder.*

It has low levels of carbon and oxygen along with good compressibility. Ancorsteel 1000 provides excellent physical properties with small additions of graphite, copper, or nickel. Ancorsteel 1000 is also available with guaranteed low levels of inclusions for powder forging applications.

Typical Analysis and Properties

Composition (weight %) (w/o)

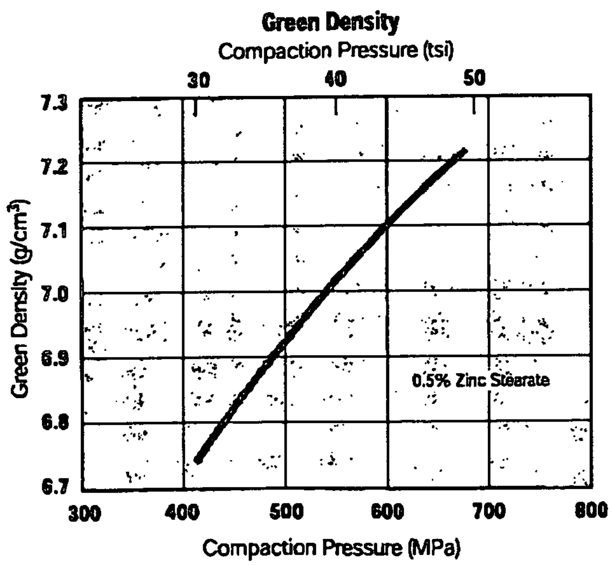
C	O	N	S	P	Si	Mn	Cr	Cu	Ni
<0.01	0.14	0.002	0.018	0.009	<0.01	0.20	0.07	0.10	0.08

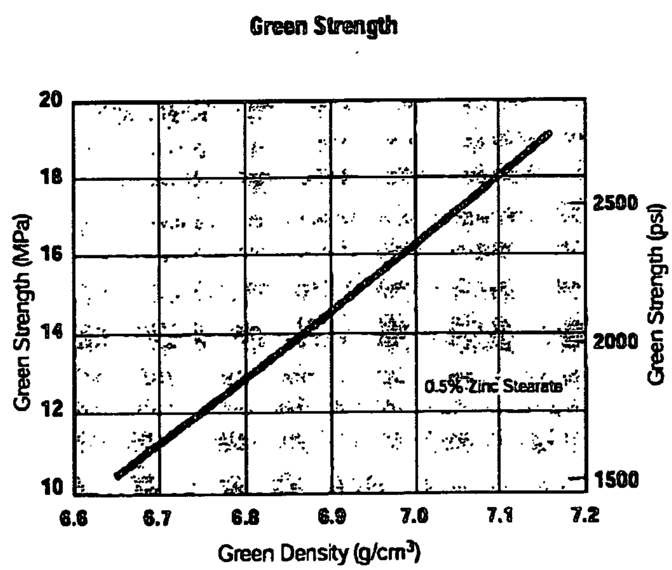
Apparent Density	Flow Rate
2.94 g/cm³	26 s/50g

Sieve Distribution (w/o)

Micrometers	+250	-250 / +150	-150 / +45	-45
U.S. Standard Mesh	(+60)	(-60 / +100)	(-100 / +325)	(-325)
	Trace	10	68	22

The Effect of Compaction Pressure on the Green Density and Green Strength of Ancorsteel 1000





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Data Sheet

Ancorsteel 1000

Ancorsteel 1000 *is the workhorse of our atomized powders, the material that had advanced P/M into the modern age of higher density compacts. More P/M components have Ancorsteel 1000 as their base than any other atomized powder.*

It has low levels of carbon and oxygen along with good compressibility. Ancorsteel 1000 provides excellent physical properties with small additions of graphite, copper, or nickel. Ancorsteel 1000 is also available with guaranteed low levels of inclusions for powder forging applications.

Typical Analysis and Properties

Composition (weight %) (w/o)

C	O	N	S	P	Si	Mn	Cr	Cu	Ni
<0.01	0.14	0.002	0.018	0.009	<0.01	0.20	0.07	0.10	0.08

Apparent Density

2.94 g/cm³

Flow Rate

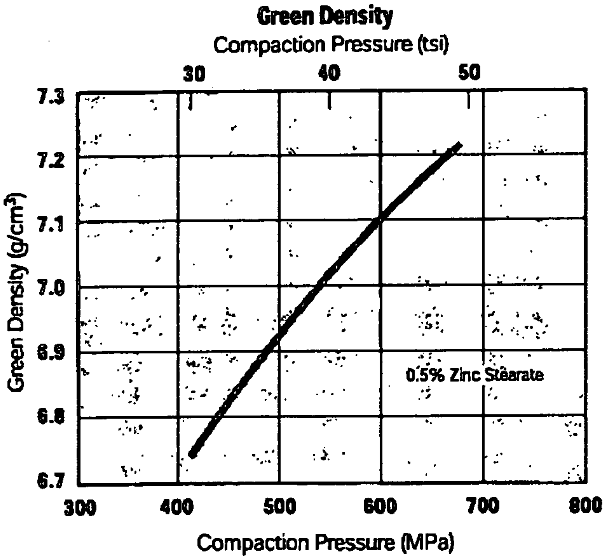
26 s/50g

Sieve Distribution (w/o)

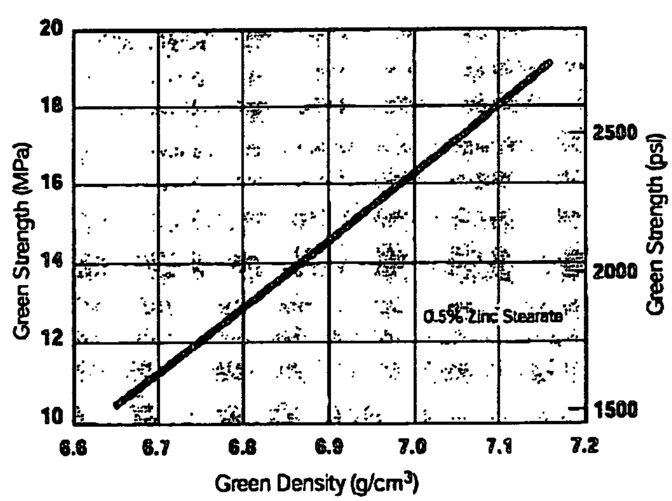
Micrometers	+250	-250 / +150	-150 / +45	-45
U.S. Standard Mesh	(+60)	(-60 / +100)	(-100 / +325)	(-325)
	Trace	10	68	22

The Effect of Compaction Pressure on the Green Density and Green Strength of Ancorsteel 1000

Green Density



Green Strength



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Data Sheet

Ancorsteel 1000

Ancorsteel 1000 *is the workhorse of our atomized powders, the material that had advanced P/M into the modern age of higher density compacts. More P/M components have Ancorsteel 1000 as their base than any other atomized powder.*

It has low levels of carbon and oxygen along with good compressibility. Ancorsteel 1000 provides excellent physical properties with small additions of graphite, copper, or nickel. Ancorsteel 1000 is also available with guaranteed low levels of inclusions for powder forging applications.

Typical Analysis and Properties

Composition (weight %) (w/o)

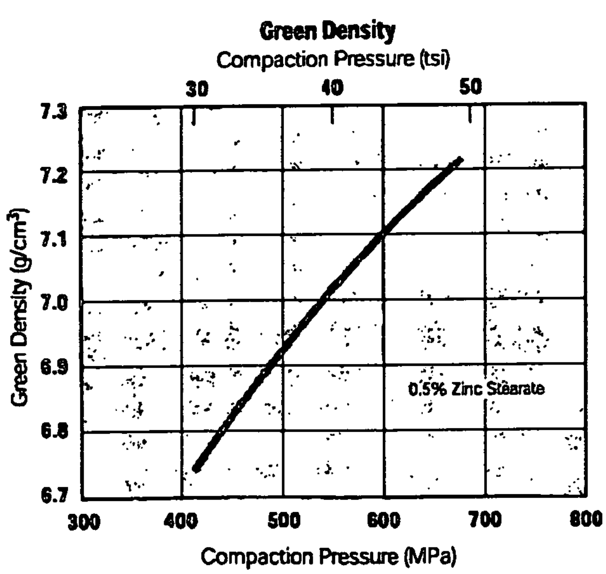
C	O	N	S	P	Si	Mn	Cr	Cu	Ni
<0.01	0.14	0.002	0.018	0.009	<0.01	0.20	0.07	0.10	0.08

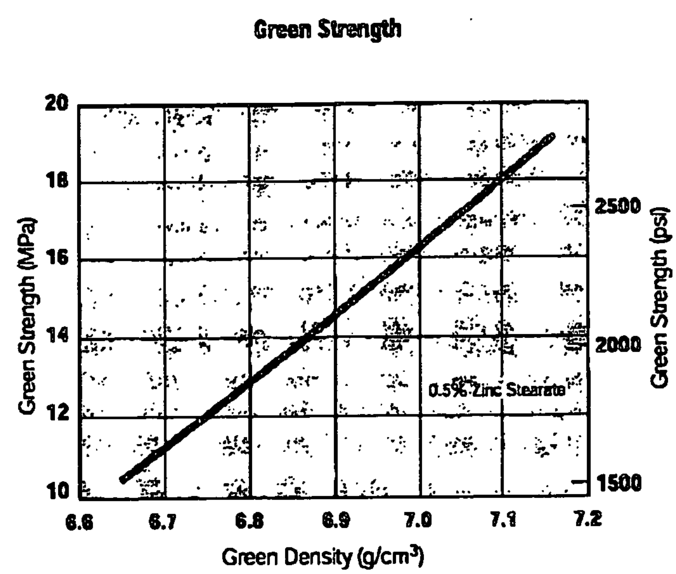
Apparent Density	Flow Rate
2.94 g/cm³	28 s/50g

Sieve Distribution (w/o)

Micrometers	+250	-250 / +150	-150 / +45	-45
U.S. Standard Mesh	(+60)	(-60 / +100)	(-100 / +325)	(-325)
	Trace	10	68	22

The Effect of Compaction Pressure on the Green Density and Green Strength of Ancorsteel 1000





Data Sheet

Ancorsteel 4600V

Ancorsteel 4600V is a water atomized low alloy steel powder containing nickel, molybdenum, and manganese which satisfies Metal Powder Industries Federation (MPIF) material specification FL-4600.

Ancorsteel 4600V is particularly useful for conventional P/M parts requiring greater hardenability than is possible when using admixed or diffusion alloyed powders. It has good compressibility and green strength, enabling parts to be made easily to densities above 6.7 g/cm³. The use of nickel and molybdenum as the principal alloying elements permits Ancorsteel 4600V to be processed using conventional P/M, temperatures and atmospheres.

Ancorsteel 4600V, because of its high degree of cleanliness and uniform chemistry, is ideally suited for powder forging (P/F) applications that require the hardenability and mechanical properties associated with cast and wrought steels. Part densities of 7.60 to 7.86 g/cm³ can be obtained using hot forming pressures of 415–1100 MPa (30–80 tsi).

Composition (weight %) (w/o)

C	Mo	Ni	Mn	O
0.01	0.56	1.83	0.15	0.13

Apparent Density

2.98 g/cm³

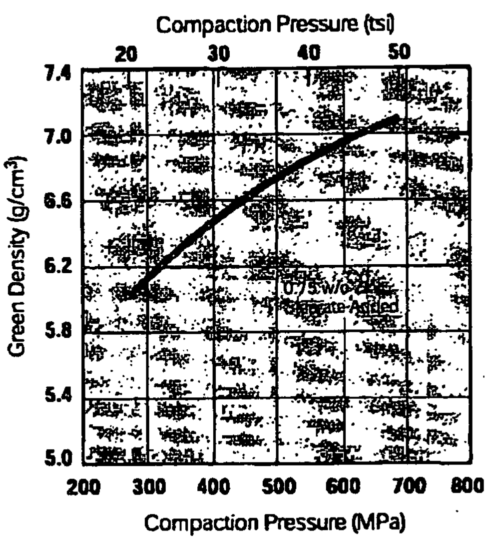
Flow Rate

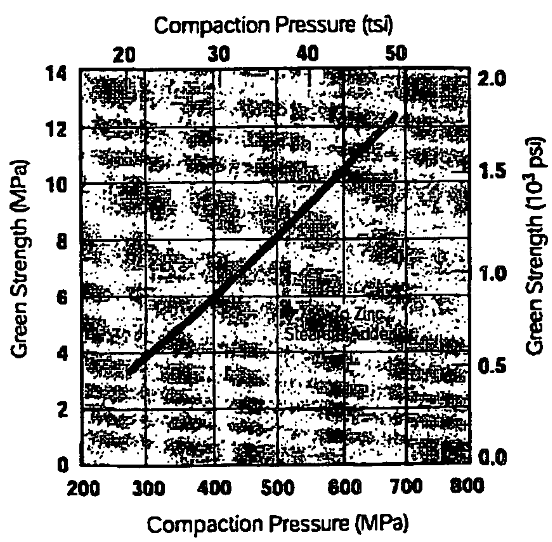
25 s/50 g

Sieve Distribution (w/o)

Micrometers	+250	-250/+150	-150/+45	-45
U.S. Standard Mesh	+60	-60/+100	-100/+325	-325
[illegible]	Trace	11	65	24

The Effect of Compaction Pressure on Green Properties





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Data Sheet

Ancorsteel 1000

Ancorsteel 1000 *is the workhorse of our atomized powders, the material that had advanced P/M into the modern age of higher density compacts. More P/M components have Ancorsteel 1000 as their base than any other atomized powder.*

It has low levels of carbon and oxygen along with good compressibility. Ancorsteel 1000 provides excellent physical properties with small additions of graphite, copper, or nickel. Ancorsteel 1000 is also available with guaranteed low levels of inclusions for powder forging applications.

Typical Analysis and Properties

Composition (weight %) (w/o)

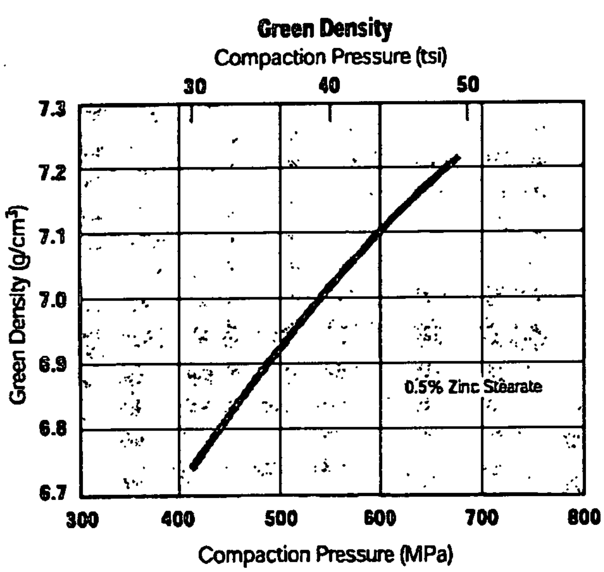
C	O	N	S	P	Si	Mn	Cr	Cu	Ni
<0.01	0.14	0.002	0.018	0.009	<0.01	0.20	0.07	0.10	0.08

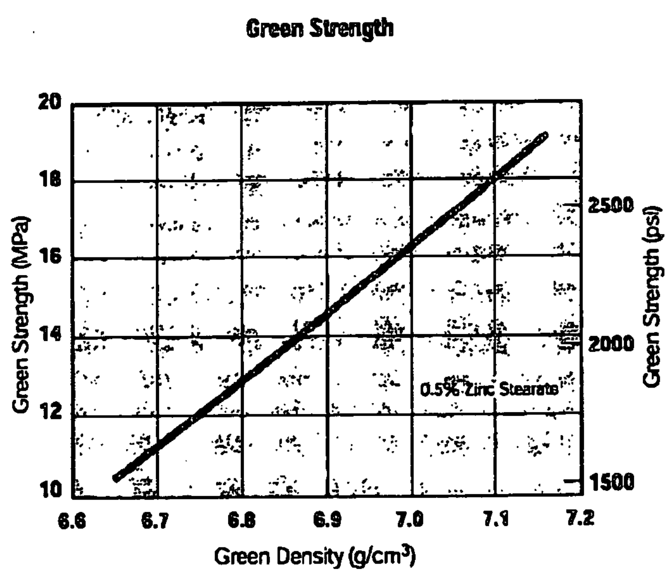
Apparent Density	Flow Rate
2.94 g/cm³	26 s/50g

Sieve Distribution (w/o)

Micrometers	+250	-250 / +150	-150 / +45	-45
U.S. Standard Mesh	(+60)	(-60 / +100)	(-100 / +325)	(-325)
	Trace	10	68	22

The Effect of Compaction Pressure on the Green Density and Green Strength of Ancorsteel 1000





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